Assessment of combined renewable power, heat and fuels production in the context of time-dependent supply and demand

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Rome, IT
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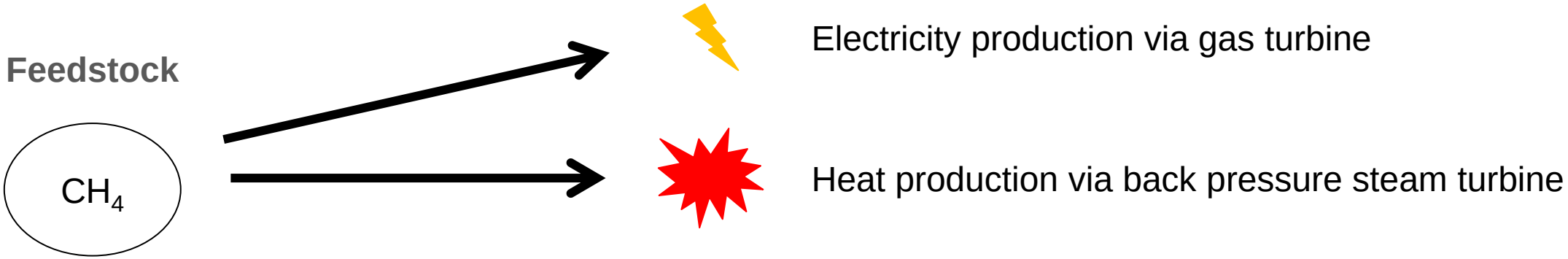
Agenda

1. **Background and motivation**
2. **Project FlexCHx**
3. **Techno-economic and ecologic assessment**
4. **Summary and Outlook**

1. Background and motivation

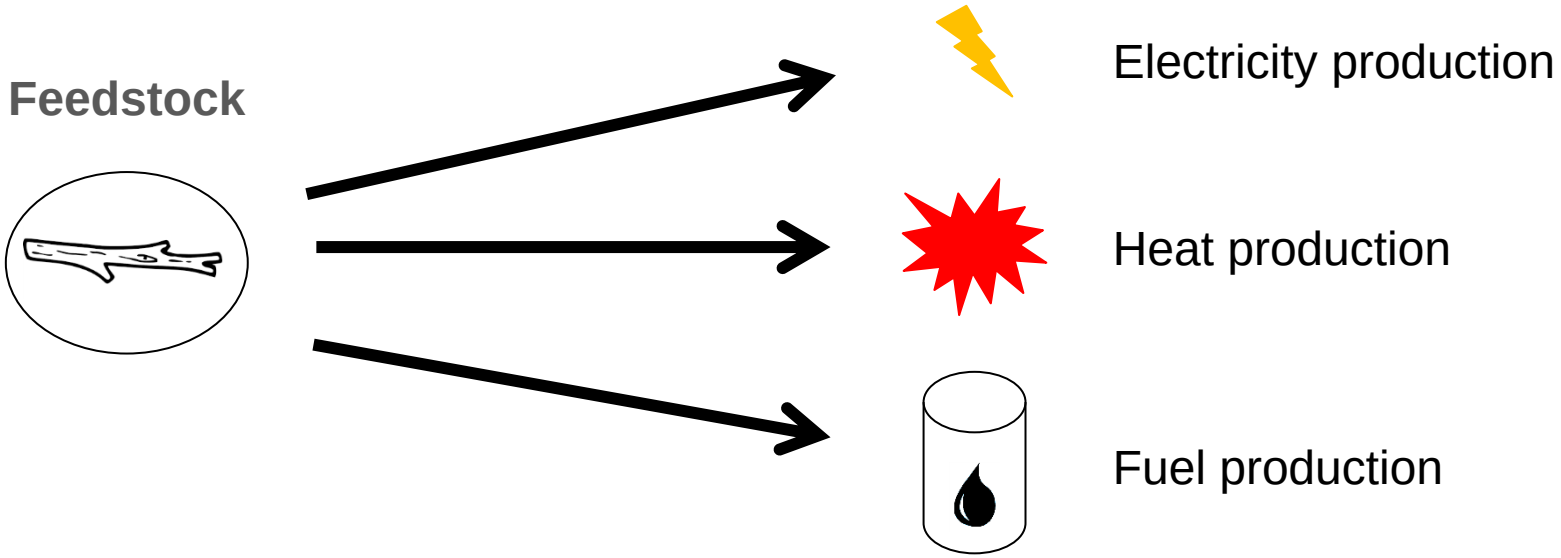
- State of the art – e.g. combined power and heat production in gas plants



- Process can be driven by electricity demand or heat demand

1. Background and motivation

- New concept - combined renewable power, heat and fuels production



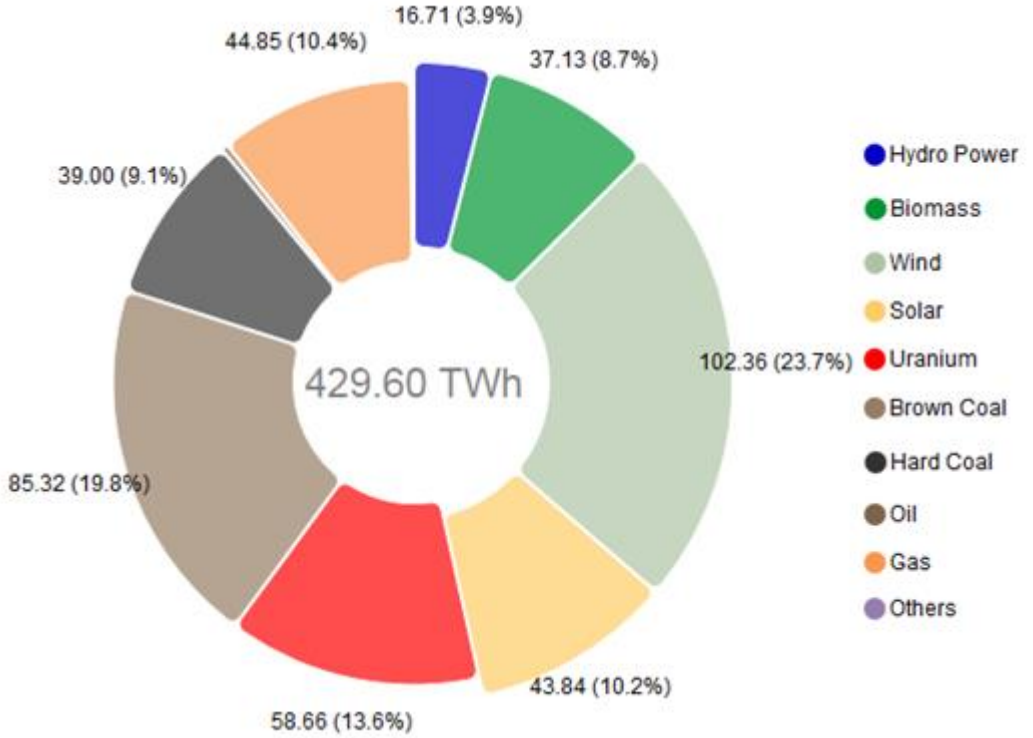
- Biomass as an exemplary “low grade” energy and carbon source for the process
- Stationary BtL process published in [1] - No time-depended aspect of demand is taken into account

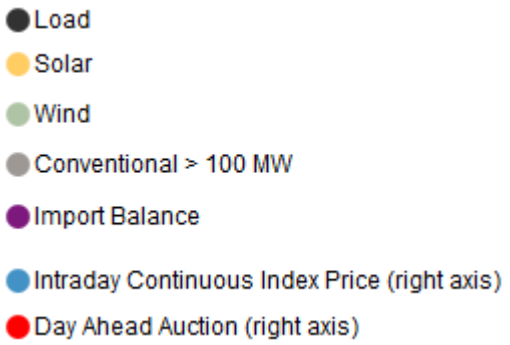
➢ Hardly no reaction to volatile electricity production and price possible - only reduction possible

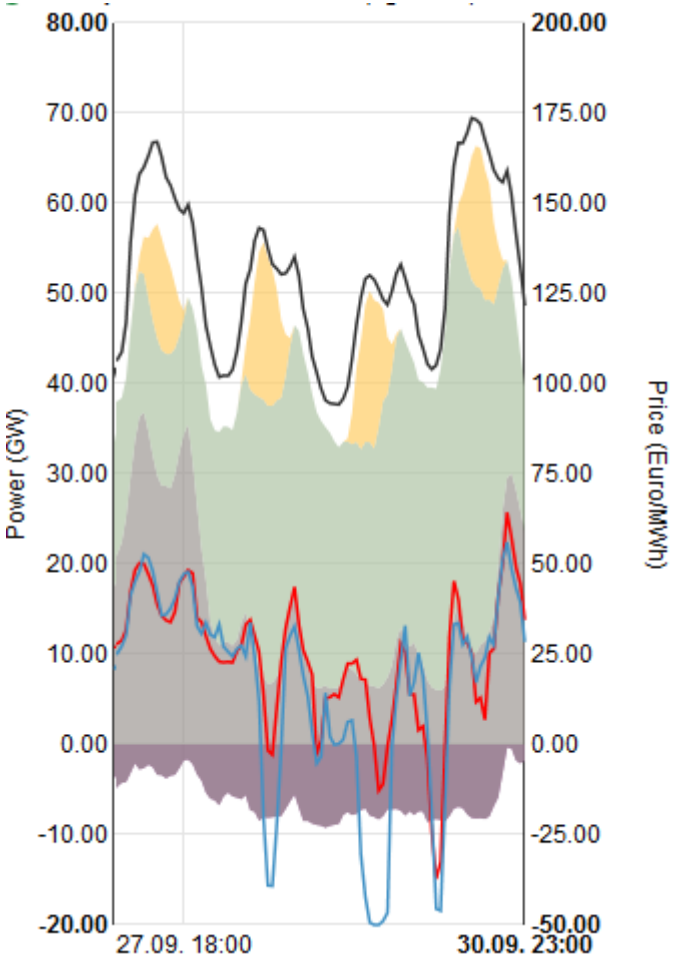
[1] Albrecht 2017 10.1016/j.fuel.2016.12.003

1. Background and motivation

- Creating a process that is capable of producing power, heat and fuels
- Participates in the electricity market – positive and negative reserve capacity







➢ Increasing share of renewables increases demand for flexible plants

Charts from www.energy-charts.de

1. Background and motivation

- No leapfrogging from stationary production processes towards plants of short-term flexibility
- First technical experience with production plants operating in different seasonal modes
- Technical challenges can be addressed for further research projects
- Simulation data obtained from different seasonal modes can be used to outline the potential of flexible production processes

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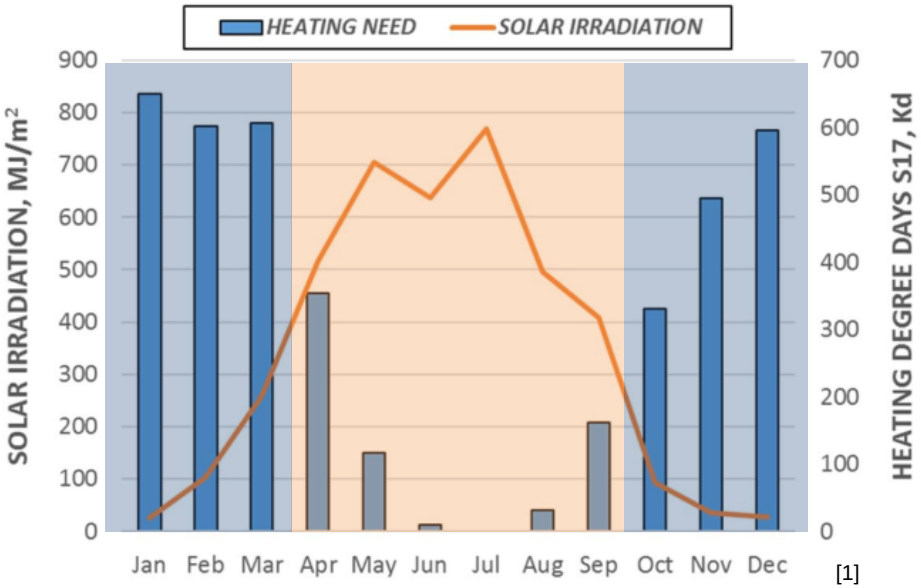
FlexCHX project has received funding from the European Union's Horizon 2020 research and innovation Programme under Grant Agreement No 763919.

2. Project FlexCHx

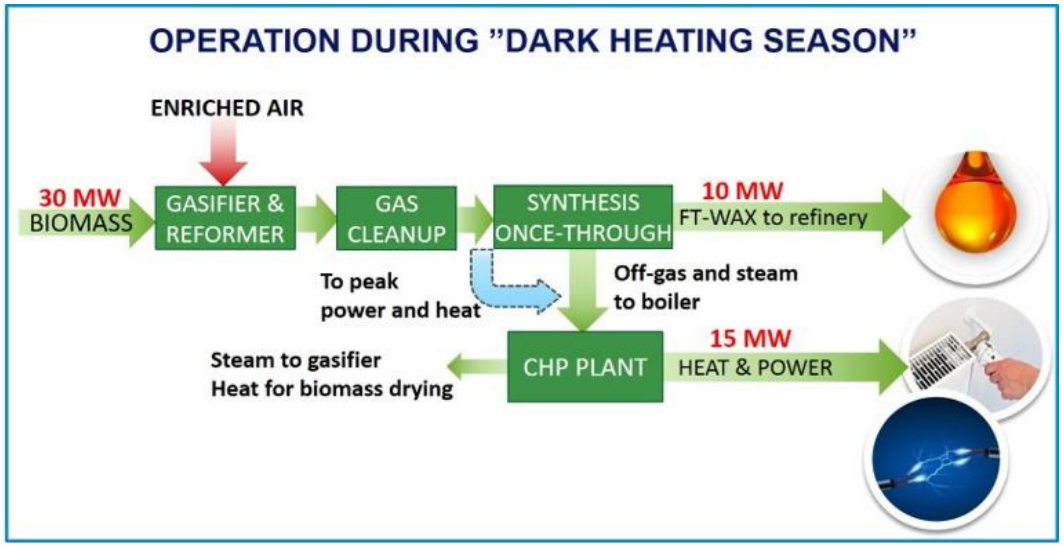
www.flexchx.eu



[1]

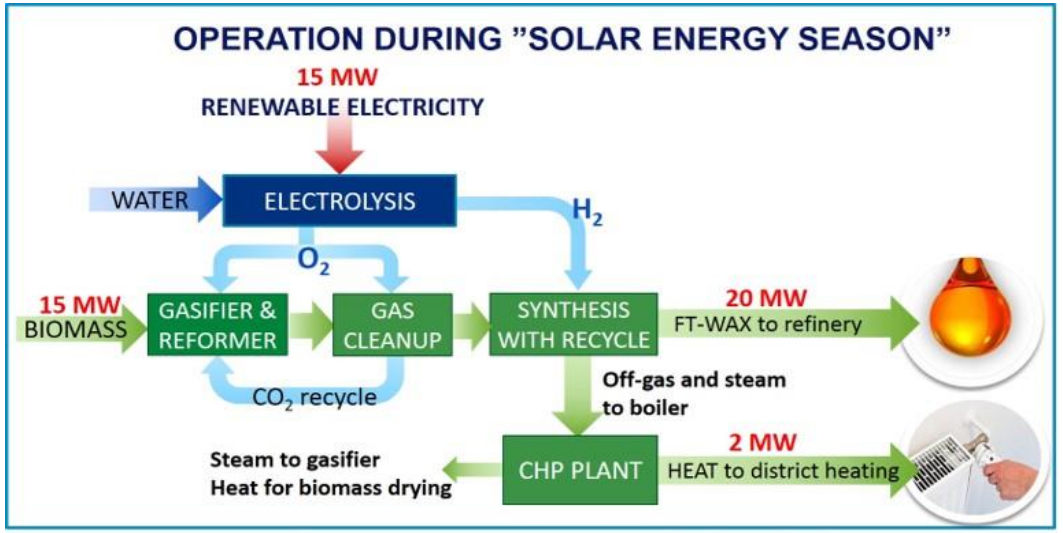
Seasonal solar irradiation and heating demand for a typical Northern European country

High heat demand & Low renewable electricity availability



[2]

Low heat demand & High renewable electricity availability



[2]

[1] https://ilmatieteenlaitos.fi/energialaskennan-testivuodet-nyky as cited in Kurkela, E. (2017) Flexible combined production of power, heat and transport fuels from renewable energy sources. Project Proposal
[2] Kurkela, E. (2017) Flexible combined production of power, heat and transport fuels from renewable energy sources. Project Proposal

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2. Project FlexCHx

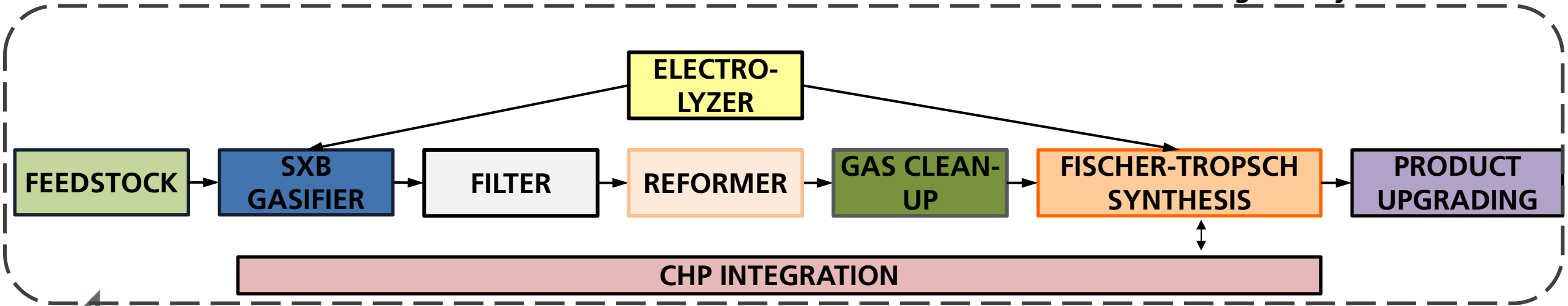
Gas clean-up

- Replacement of conventional gas cleaning processes (Rectisol/Selexol) by a cost-effective sorbent based cleaning process
- Testing of the cleaning process in conjunction with the SXB gasifier

Process highlights:

- Large range of possible feedstock
- Tar removal in the gasifier
- No gas cooling for the filter required
- Flexible electrolyzer with oxygen storage
- Autothermal reforming
- Cost-efficient gas clean-up
- FT By-pass for high heat demand

Techno-economic & ecologic analysis



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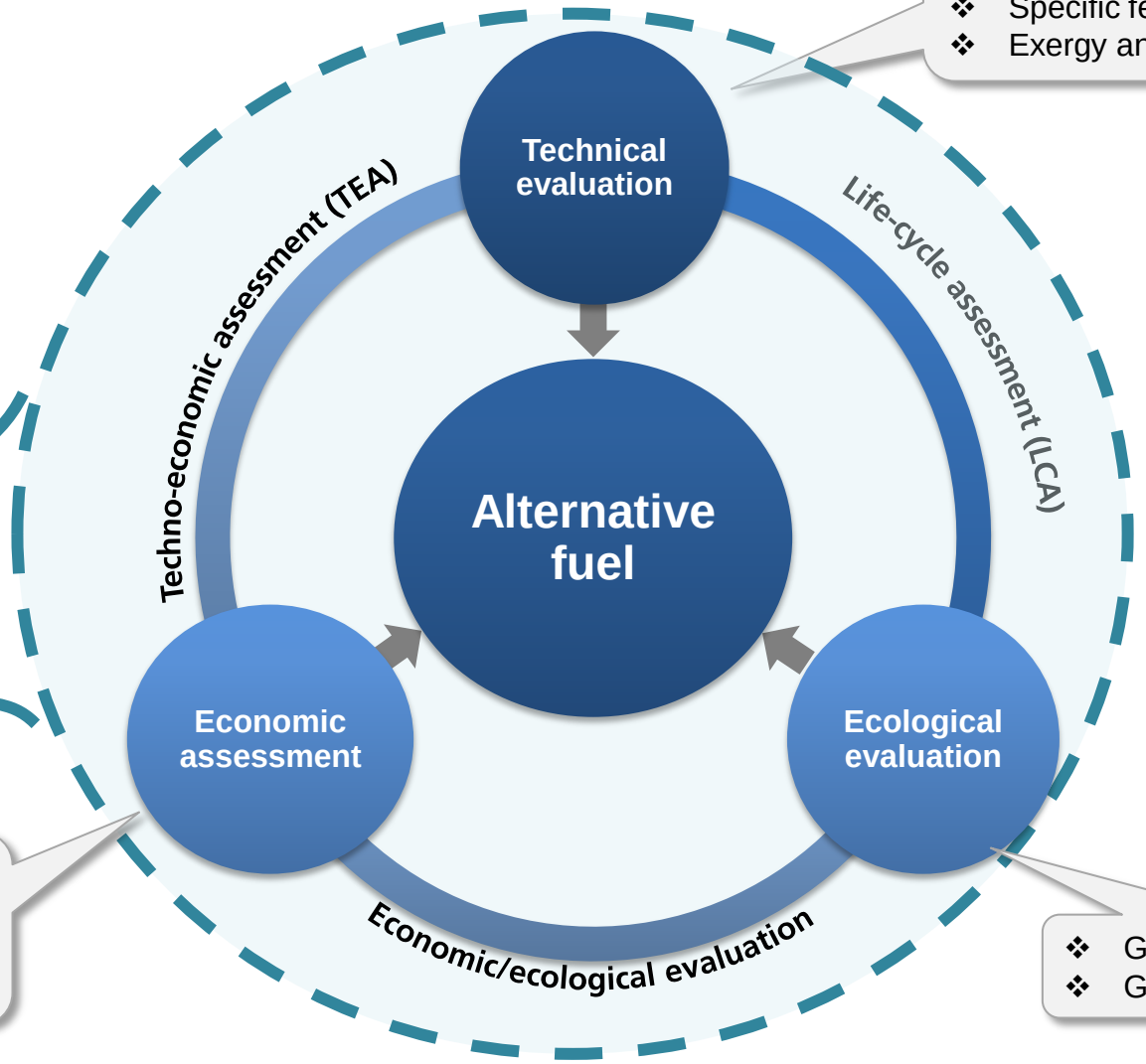
3. Techno-economic and ecological assessment (TEEA)

DLR's Techno economic process evaluation tool



- Efficiencies (X-to-Liquid, Overall)
- Carbon conversion
- Specific feedstock demand
- Exergy analysis

- CAPEX, OPEX, NPC
- Sensitivity analysis
- Identification of most economic feasible process design

- GHG-footprint
- GHG-abatement costs

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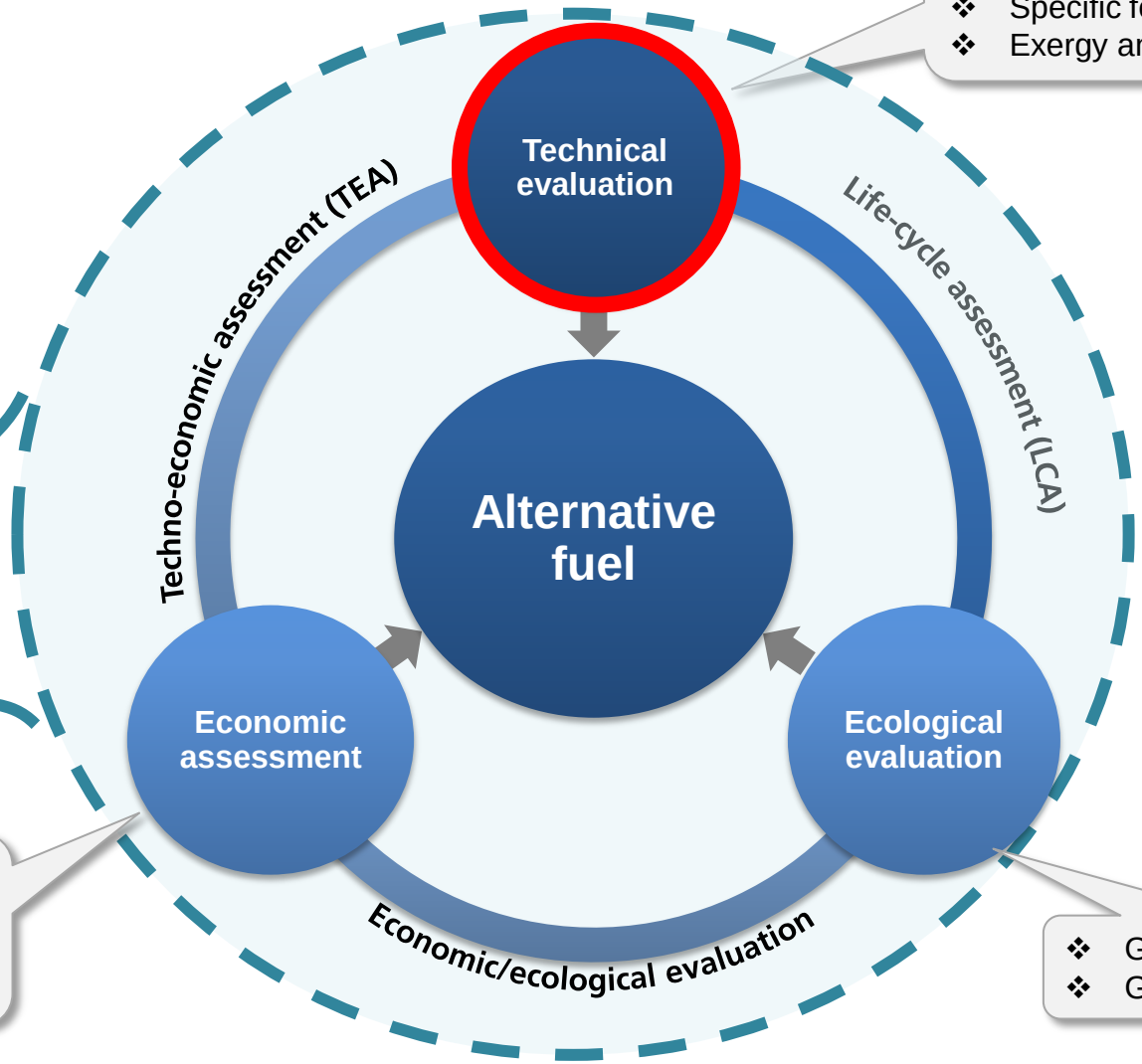

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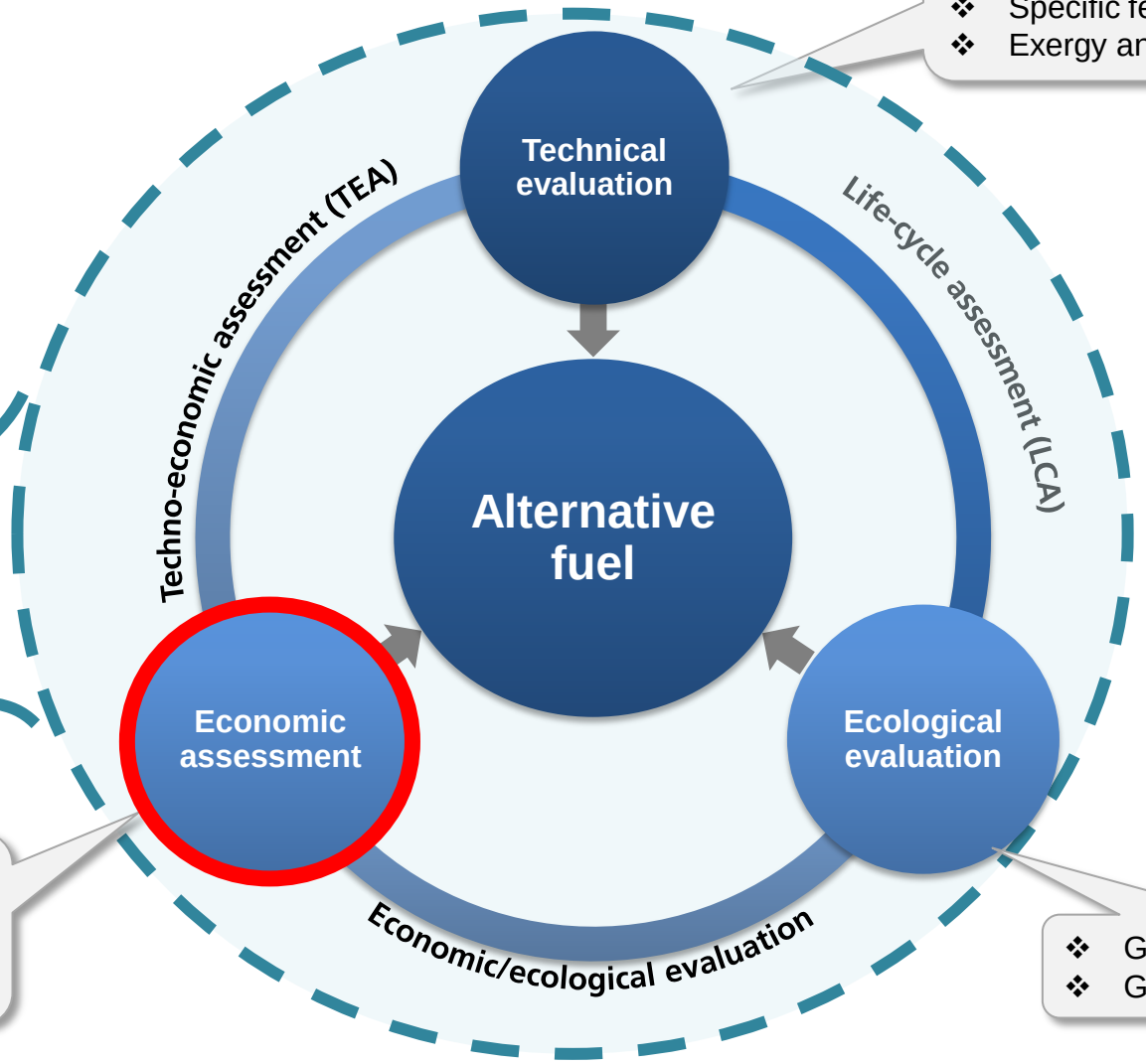

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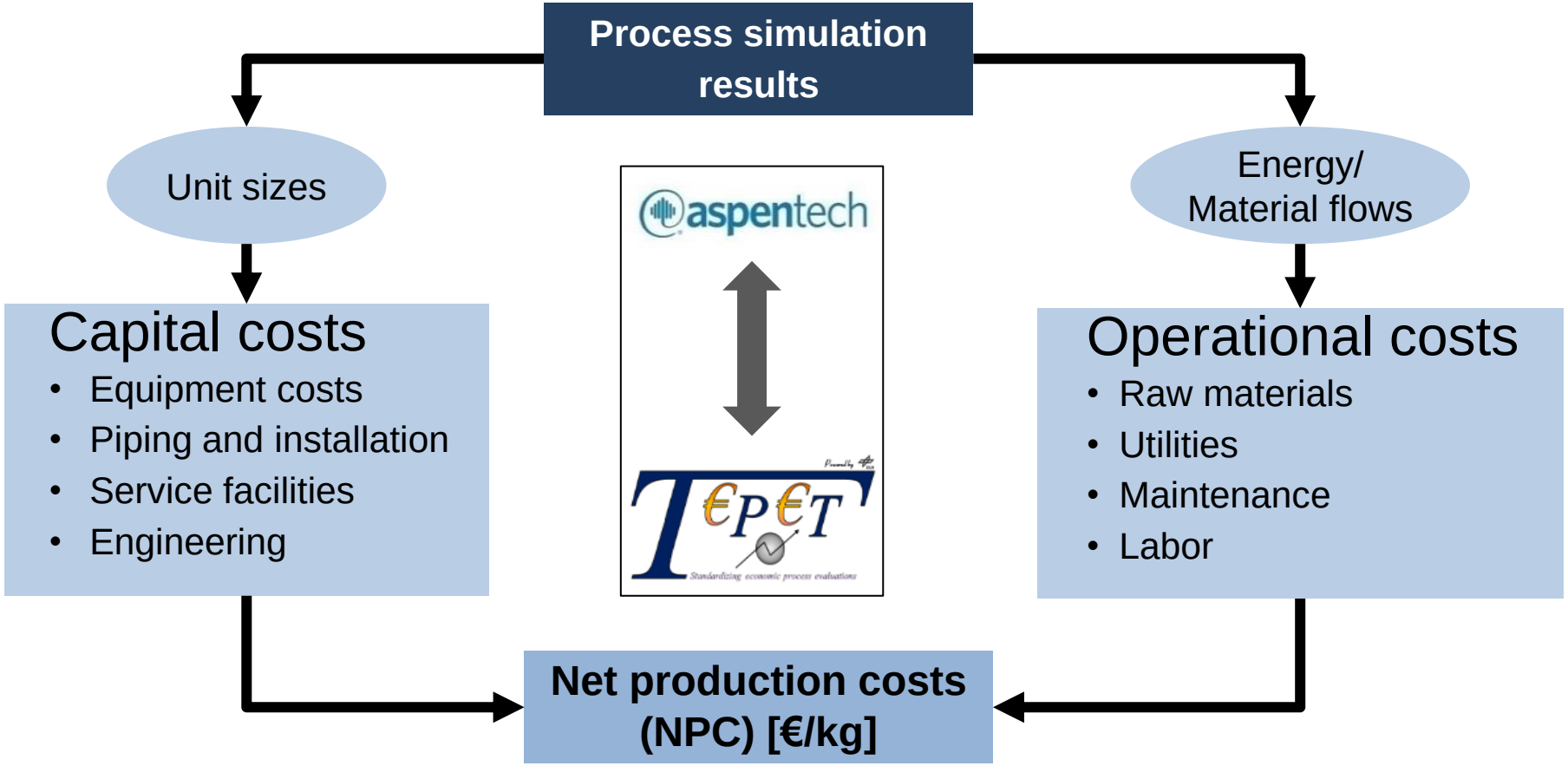
3. Techno-economic and ecological assessment (TEEA)

- adapted from **best-practice chem. eng. methodology**
- Meets AACE class 3-4, Accuracy: **+/- 30 %**
- **Year specific** using annual CEPCI Index
- Automated interface for **seamless integration**
- Easy sensitivity studies for **every** parameter
- Learning curves, economy of scale, …



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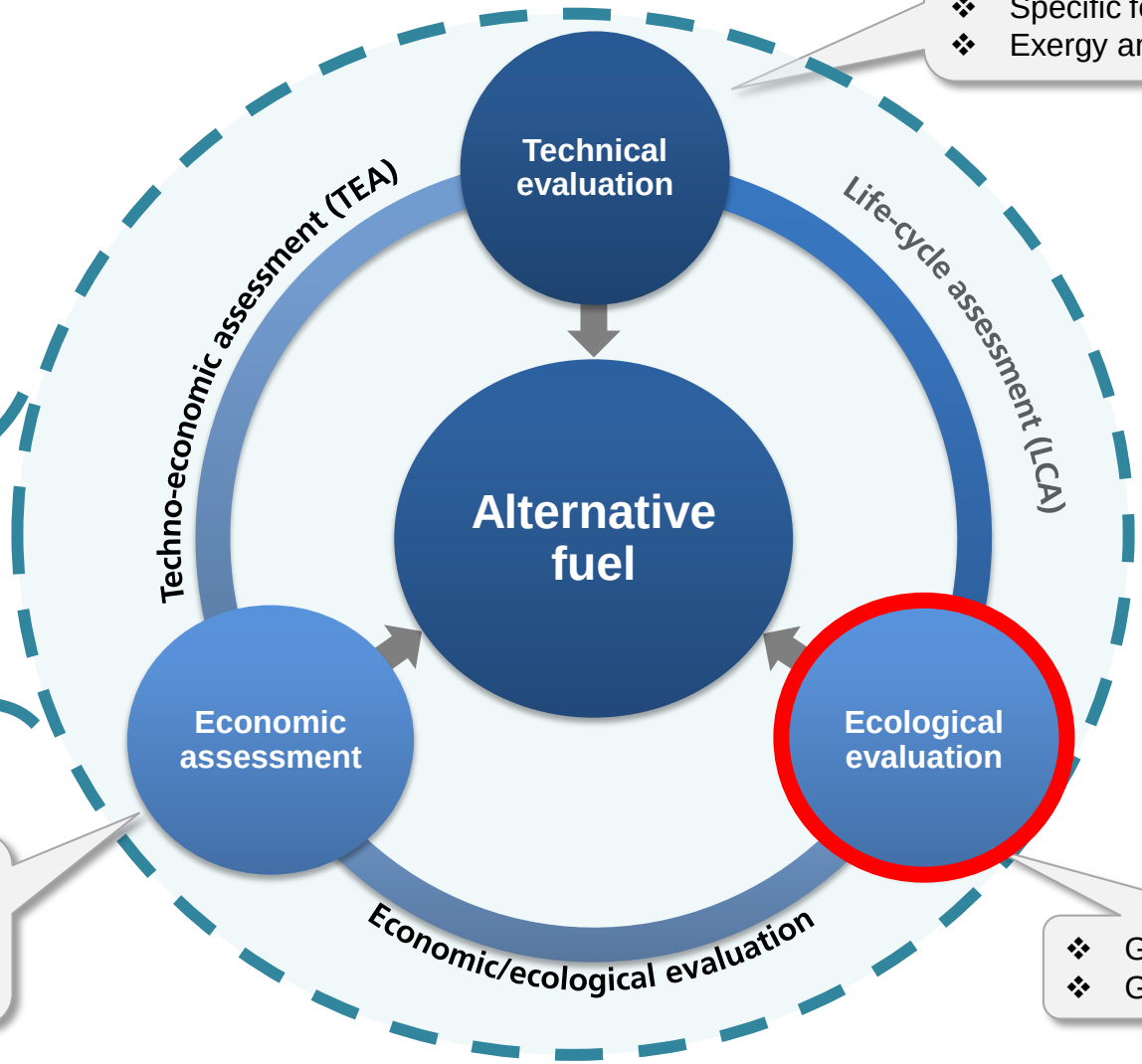

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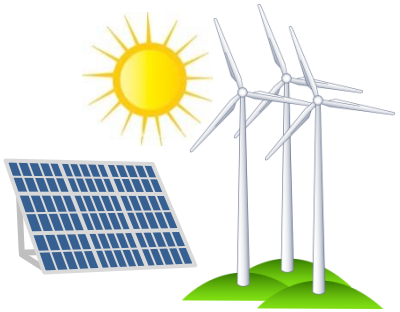
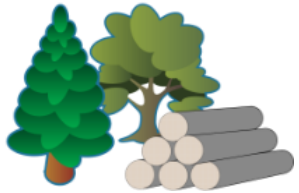


Electricity footprint



Biomass footprint

Plant emissions

Efficiency

System integration

GHG-footprint of products

Electricity

Heat

Fuel

Application efficiency

$$\text{GHG abatement costs} \left[\frac{€}{t_{CO_2eq.}}\right] = \frac{\text{Difference in production costs}}{\text{GHG abatement}}$$

Car - http://aktionberlinerallee.de/
Wind turbine: http://clipartbarn.com/wind-turbine-clipart_15864/

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- “Gate to gate” Techno-economic and ecological assessment of two operating modes are assessed
- With (future) data for electricity supply and demand more flexible operating modes can be evaluated
- Results of “Gate to gate” assessment can be used in a model with larger perspective
  - Influence of several plants on an electric grid
  - Fuel production capacity as a function on electricity supply and demand
- Including the usage of the products and the corresponding efficiencies different optimizations can be carried out
  - What is the most economic running mode for the plants
  - What running mode has the least GHG emissions

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Thank you for your attention

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